

- [54] **TONE KEYING AND SYNTHESIZING SYSTEM FOR ELECTRONIC MUSICAL INSTRUMENT**
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- [73] Assignee: **Nippon Gakki Seizo Kabushiki Kaisha**, Hamamatsu-shi, Shizuoka-ken, Japan
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- [21] Appl. No.: **312,680**

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Primary Examiner—Stephen J. Tomskey
Assistant Examiner—Stanley J. Witkowski
Attorney, Agent, or Firm—Flynn & Frishauf

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Feb. 10, 1972 Japan..... 47-14687
Feb. 10, 1972 Japan..... 47-14688
- [52] U.S. Cl..... **84/1.01, 84/1.22, 84/1.24, 84/DIG. 4**
- [51] Int. Cl..... **G10h 1/02, G10h 5/06**
- [58] Field of Search..... **84/1.01, 1.03, 1.11-1.13, 84/1.19-1.26, DIG. 11, DIG. 2, DIG. 4**

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[57] **ABSTRACT**

First and second latching selectors receive tone signals from the tone generators and are operatively coupled to a keyboard for respectively deriving first and second tone signals having frequencies determined by the depressed keys in the keyboard. The frequencies of the first and the second tone signals are respectively divided by first and second frequency dividers respectively having predetermined dividing factors of, for example, 2 and 3, so that the first and the second frequency divided tone signals (i.e., the signals at the outputs of the frequency dividers) have a frequency ratio which is close to but not exactly equal to an integer. The mixed resultant tone exhibits an ensemble effect as produced by a multi-series tone generator.

23 Claims, 8 Drawing Figures

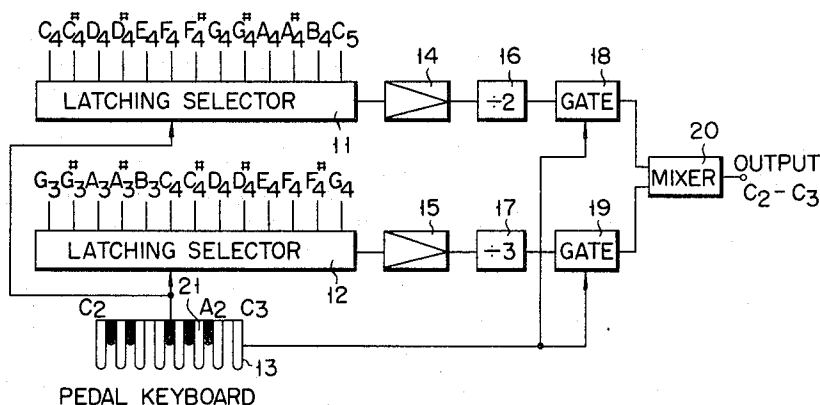


FIG. 1

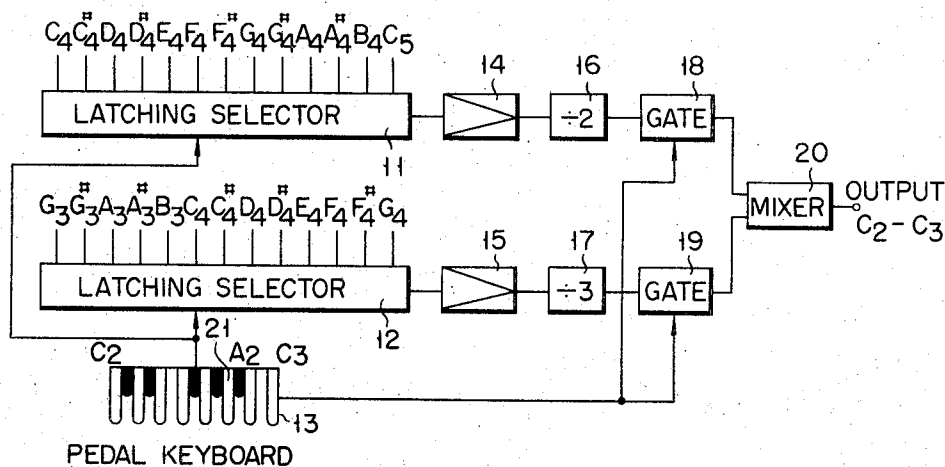


FIG. 2

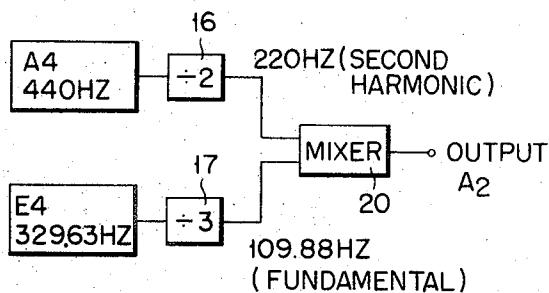


FIG. 3

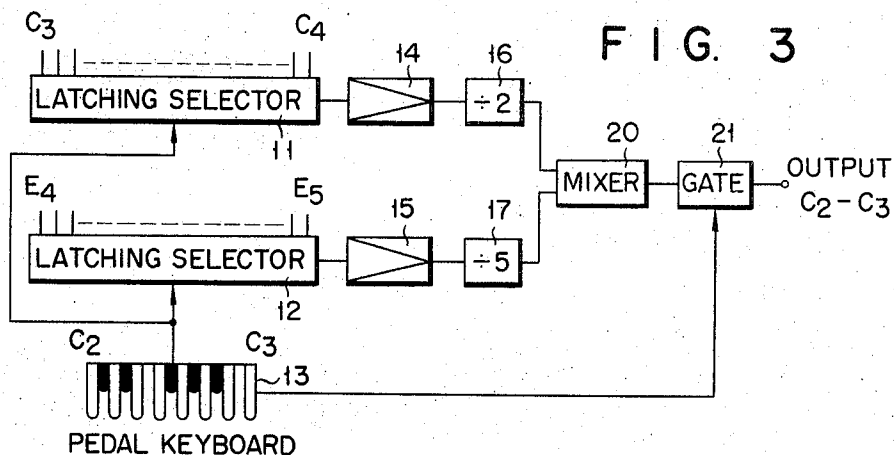


FIG. 4

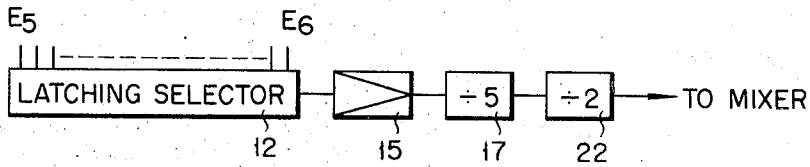


FIG. 5

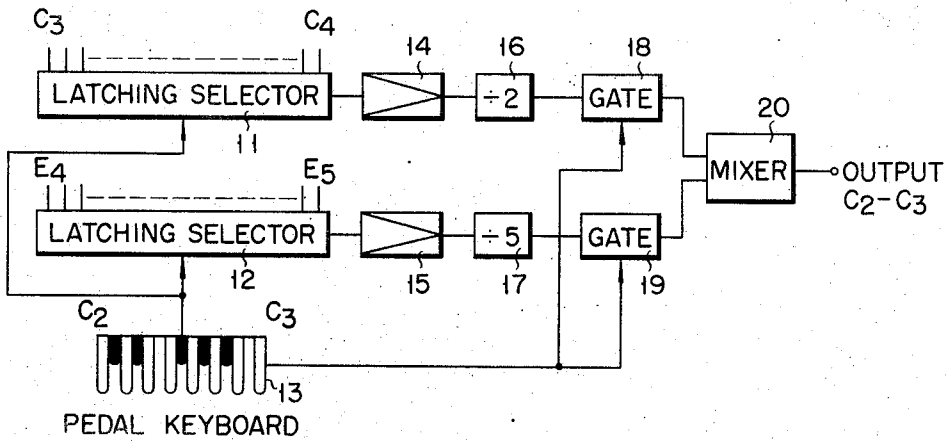


FIG. 6

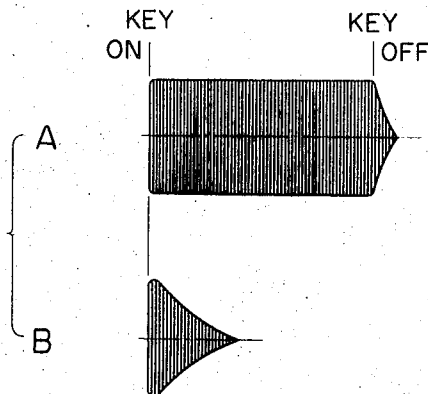


FIG. 7

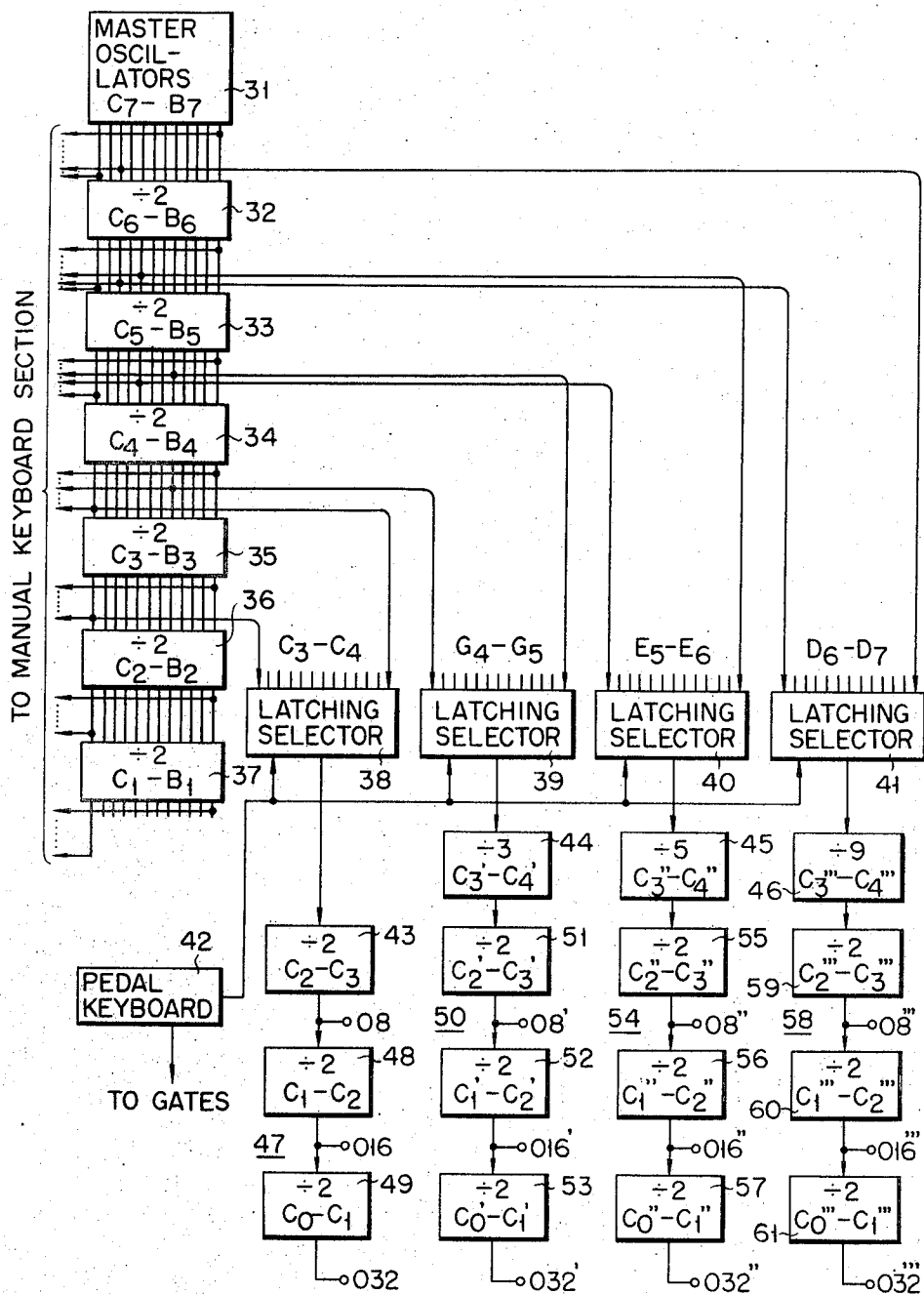
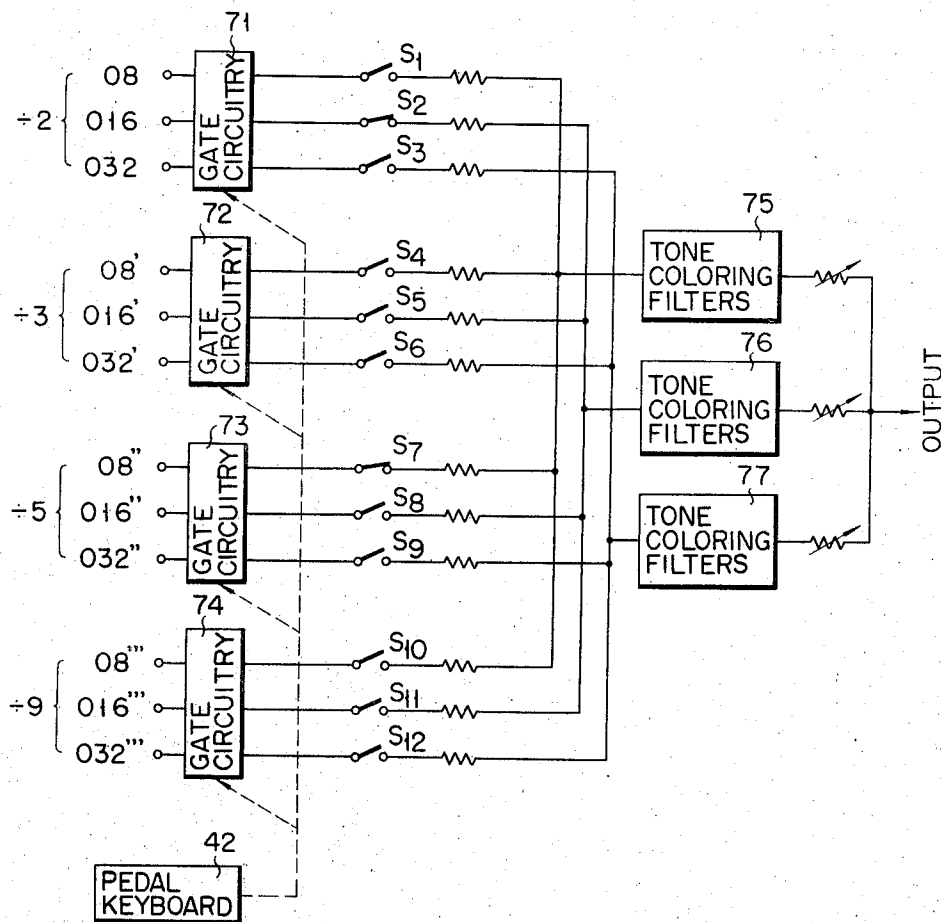


FIG. 8



TONE KEYING AND SYNTHESIZING SYSTEM FOR ELECTRONIC MUSICAL INSTRUMENT

This invention relates to a tone keying and synthesizing system for an electronic musical instrument and more particularly to a tone keying and synthesizing system capable of rendering tones which are artificially produced by electronic musical instruments truthful to those obtained from natural musical instruments.

Tones derived from natural musical instruments have the following features. First, the fundamental waves and harmonics are not locked together in phase and in frequency. Secondly, the harmonic components produce humming sounds. Thirdly, when tones begin to be generated, or at the rise of tones, there appear relatively fast attenuating harmonic components whose frequencies do not represent an integral multiple of that of the fundamental waves. Therefore, at the starting moments or rises of the tones, they have unstable pitch frequencies.

The prior art electronic musical instrument will now be discussed in connection with the above-mentioned first feature of tones obtained from natural musical instruments. In a conventional electronic musical instrument, output signals from the master oscillators have their frequency successively divided by two to produce a plurality of octavely related tone signals. Therefore, the mixed fundamental and harmonic tone signals are unavoidably locked in phase. To resolve this drawback, some of the prior art electronic musical instruments mix fundamental tone signals having the frequency divided by two with harmonic tone signals having the frequency divided by an odd number. For example, a tone signal corresponding to note C2 (65.406 Hz) has a frequency to provide, when divided by two, a signal denoting a fundamental wave of note C1 (32.703 Hz). A tone signal corresponding to note G3 (195.998 Hz) has a frequency to produce, when divided by three, a signal having a frequency of 65.333 Hz (a second harmonic wave of note C1). Both the fundamental wave and the harmonic component thus obtained are mixed in an attempt to attain truthfulness to the tones of natural musical instruments. According to such approach, however, formation of a tone signal representing note C1 requires tone signals or tone generators denoting notes C2 and G3 separated more than one octave from each other, resulting in a complicated circuit arrangement of tone generators.

The aforesaid second feature of tones obtained from natural musical instruments can not be simulated simply by mixing octavely related tone signals.

Further to simulate the third feature of natural musical instruments, some of the conventional electronic musical instruments cause the frequency of a tone signal to be shifted during the short period in which a key is depressed. This process can indeed vary the frequency of the rising portion of a sustained tone, but fails to attain truthfulness to the tones of natural musical instruments due to the absence of a fundamental wave in the rising portion of the tone being produced.

It is accordingly the object of this invention to provide an electronic musical instrument capable of producing tones truthful to those of natural musical instruments by a simple circuit arrangement of tone keying and synthesizing circuits.

SUMMARY OF THE INVENTION

An electronic musical instrument according to this invention is provided with at least first and second latching selectors operatively coupled with keys in a keyboard and having input terminals normally supplied with tone signals and deriving upon key depression first and second tone signals having frequencies determined by the depressed key. The first and the second tone signals have their frequencies divided by first and second frequency dividers having frequency dividing factors of first and second predetermined numbers, either of which does not constitute a power of a number 2 (i.e., $2^1, 2^2, 2^3, \dots$) with respect to the other. Outputs from the frequency dividers are mixed by a mixer.

Since the first and the second frequency dividers carry out frequency division by the numbers, either of which does not represent a power of 2 with respect to the other, output signals from the frequency dividers are not in exact integer relationship. Where the output of the first frequency divider should constitute a fundamental wave and that of the second frequency divider a harmonic component thereof, it is only required that the frequency of the output of either of these two frequency dividers be a substantially integral multiple (at least 2) of the frequency of the other. If the outputs of the first and second frequency dividers are purposely made to have frequencies bearing a ratio of substantially 1, then the fundamental waves or harmonic components will be accompanied with humming as is observed in the tones of natural musical instruments.

Further, between the first frequency divider and the input terminal of the mixer is provided a first gate for supplying a first tone signal with a sustained envelope. Between the second frequency divider and the mixer input terminal is positioned a second gate for supplying a second tone signal with a decaying envelope. Accordingly, when tones begin to be generated, they have unstable pitch frequencies.

The present invention can be more fully understood from the following detailed description when taken in connection with the accompanying drawings, in which:

FIG. 1 is a block diagram of a tone keying and synthesizing system for an electronic musical instrument according to a first embodiment of this invention;

FIG. 2 is a schematic illustration for better understanding of the operation of the system of FIG. 1;

FIG. 3 is a block diagram of a tone keying and synthesizing system according to a second embodiment of the invention;

FIG. 4 is a modification of FIG. 3;

FIG. 5 is a block diagram of a tone keying and synthesizing system according to a third embodiment of the invention;

FIGS. 6A and 6B present the envelope forms of tone signals produced by the tone keying and synthesizing system of FIG. 5; and

FIGS. 7 and 8 are block diagrams, in combination, of a tone keying and synthesizing system according to still another embodiment of the invention.

FIG. 1 is a block diagram of a tone keying and synthesizing system according to a first embodiment of this invention, showing the manner in which there are mixed a fundamental wave and its harmonic component. Reference numerals 11 and 12 represent the known first and second latching selectors. These latch-

ing selectors 11 and 12 are connected to receive tone signals of notes C4 to C5 and those of notes G3 to G4 respectively. The latching selectors 11 and 12 are further operatively coupled to a pedal keyboard 13 having keys representing notes C2 to C3, thereby producing upon key depression first and second tone signals bearing a predetermined frequency relationship. The latching selectors 11 and 12 are respectively so designed as to derive a single tone signal even when there are simultaneously depressed a plurality of keys of the pedal keyboard 13.

Where there is depressed a key 21 of the pedal keyboard 13 corresponding to, for example, note A2, the first latching selector 11 draws out a first tone signal representing note A4, and the second latching selector 12 draws out a second tone signal denoting note E4. These first and second tone signals are supplied to amplifiers 14 and 15 and then to a first frequency divider 16 having a division ratio of 2 and a second frequency divider 17 having a division ratio of 3, so as to be subjected to frequency division to become an A3 signal and an approximate A2 signal respectively. After the frequency division, the first and second tone signals are conducted to first and second gate circuits 18 and 19 later to be mixed together in a mixer 20. The first and second gate circuits 18 and 19, which may be of a known type, are operatively coupled to the pedal keyboard 13 to permit the passage of tone signals only upon key depression. Details and correlations of the latching selectors, the keyboard and gates are of such known construction as is disclosed in the U.S. Pat. No. 3,598,892 to Yamashita.

There will now be described the operation of the tone keying and synthesizing system of FIG. 1. When there is depressed the key 21 of the pedal keyboard 13 corresponding to note A2, there are derived, as described above, a first tone signal representing note A4 (440 Hz) and a second tone signal denoting note E4 (329.63 Hz). As shown in FIG. 2, the first tone signal has its frequency divided into a signal having a frequency of 220 Hz by the first frequency divider 16 and the second tone signal into a signal having a frequency of 109.88 Hz by the second frequency divider 17. An output from the second frequency divider 17 corresponds to the fundamental wave of the tone signal representing note A2 and an output from the first frequency divider 16 represents the second harmonic wave of the tone signal corresponding to note A2. From the output terminal of the mixer 20 are obtained a fundamental wave and a second harmonic wave having a frequency close to but not exactly twice of the fundamental frequency, thereby producing a tone approximately truthful to that of a natural musical instrument. To obtain a tone signal corresponding to note A2, there are required tone generators associated with notes A4 and E4 included in the range of one octave, thus simplifying the circuit arrangement of tone generators.

Where the tone keying and synthesizing system of FIG. 1 is employed as a pedal keyboard playing section in an electronic organ including a manual keyboard playing section of a conventional frequency dividing tone generator system, the organ can produce a good ensemble effect, because the fundamental wave of the pedal tone is obtained by a frequency division by an odd number (3 in FIG. 1) whereas the fundamental waves of the manual tones are obtained by a frequency

division by an even number (usually, 2, 4, 8, ...), both being not in an exact integer relationship.

The foregoing description refers to the case where there were obtained the fundamental wave of note A2 and its second harmonic component. To obtain a tone signal representing note C1 (32.70 Hz), there may be used any of the following processes:

Process 1

C4(261.64 Hz)	÷2	130.81 Hz = fourth harmonic of C1
G3(196.00 Hz)	÷3	65.33 Hz = second harmonic of C1
E3(164.81 Hz)	÷5	32.96 Hz = fundamental wave of C1

Process 2

C5(523.25 Hz)	÷2	261.63 Hz = eighth harmonic of C1
G4(392.00 Hz)	÷3	130.67 Hz = fourth harmonic of C1
E4 (329.63 Hz)	÷5	65.93 Hz = second harmonic of C1
D4 (293.67 Hz)	÷9	32.63 Hz = fundamental wave of C1

Process 3

C4(261.63 Hz)	÷2	130.81 Hz = fourth harmonic of C1
D4(293.67 Hz)	÷3	97.89 Hz = third harmonic of C1
E4(329.63 Hz)	÷5	65.93 Hz = second harmonic of C1
D4(293.67 Hz)	÷9	32.63 Hz = fundamental wave of C1

As mentioned above, to produce a tone signal, it is advised that the frequency division ratio for the fundamental wave is the largest and odd number used in the frequency division of each process which does not constitute a power of 2 with respect to a frequency division ratio for a harmonic component.

FIG. 3 is a block diagram of a tone keying and synthesizing system according to a second embodiment of this invention which is intended to introduce a humming effect into the tones generated thereby. The parts of FIG. 3 the same as those of FIG. 1 are denoted by the same numerals. The first latching selector 11 is supplied with tone signals corresponding to notes C3 to C4 (130.81 Hz to 261.63 Hz), and the second latching selector 12 with tone signals representing notes E4 to E5 (329.63 Hz to 659.26 Hz) which respectively have a pitch one octave and major third higher than notes C3 to C4. A second frequency divider 17 effects frequency division by 5. A gate circuit 21 is connected to the output side of the mixer 20.

The first tone signal derived from the latching selector 11 has its frequency divided by the first frequency divider 16 into a frequency within 65.40 to 130.81 Hz, and the second tone signal derived from the latching selector 12 has its frequency divided by the second frequency divider 17 into 65.92 to 131.85 Hz. Therefore, between the divided frequency of the first tone signal and that of the second tone signal, there is a difference of 13.6 cents, namely, there arises a humming sound having a beat frequency of 0.52 to 1.04 Hz. Thus the intermediate frequency region of a bass tone contains a humming sound having a frequency of about 1 Hz.

If the second latching selector 12 were supplied with tone signals corresponding to notes G3 to G4 (196.00 Hz to 392.00 Hz) and the second frequency divider 17

effects frequency division by 3, then the divided frequencies of the first and second tone signals would have a difference of only 2 cents. Thus the frequency difference would be reduced to only about 0.2 Hz at the middle of the output octave region. Such a small frequency difference would produce no significant effect particularly for a quick performance.

If the second frequency divider 17 carries out frequency division by seven or nine, then the divided frequencies of the first and second tone signals would have a difference of 65 or 4 cents. A difference of 65 cents is too large, while a difference of 4 cents is too small. Therefore, the second frequency divider 17 is most preferred to effect frequency division by five.

Referring to FIG. 3, the second tone signal has its frequency divided by five. However, the frequency divided output wave does not have a 50 percent duty factor, giving rise to an unsatisfactory tone color. This drawback can be eliminated by supplying the second latching selector 12, as shown in FIG. 4, with tone signals representing the notes E5 to E6 which respectively have a pitch one octave higher than those corresponding to the notes E4 to E5 as are employed in FIG. 3, and further connecting a third frequency divider 22 effecting frequency division by 2 to the output side of the second frequency divider 17.

FIG. 5 is a block diagram of a tone keying and synthesizing system according to a third embodiment of this invention which is capable of causing tone signals to have unstable pitch frequencies when they begin to be generated. The parts of FIG. 5 the same as those of FIG. 1 are denoted by the same numerals. As in FIG. 3, the first latching selector 11 is supplied with tone signals corresponding to notes C3 to C4, and the second latching selector 12 with tone signals representing notes E4 to E5. The second frequency divider 17 effects frequency division by 5. A first gate circuit 18 supplies an output from the first frequency divider 16 with a sustained envelope indicated in FIG. 6A. A second gate circuit 19 supplies an output from the second frequency divider 17 with a percussive envelope as shown in FIG. 6B. These gate circuits have a known arrangement, such as those shown in U.S. Pat. No. 3,571,481 to Adachi, and description thereof is omitted.

As long as the output from the second frequency divider 17 has a frequency bearing a ratio of approximately one to that of the first frequency divider 16, the second frequency divider 17 may carry out frequency division by three or seven in place of five. The tone keying and synthesizing system of FIG. 5 causes tone signals to have unstable pitch frequencies during the extremely short period at the starting moment of the tone sounding in spite of the presence of a fundamental pitch and thereafter causes the tone signals to have a sustained stable pitch frequency, thereby producing tones truthful to those of natural musical instruments.

There will now be described a tone keying and synthesizing system according to a fourth embodiment of this invention shown in FIGS. 7 and 8 in combination. Output signals from master oscillators 31 representing notes C7 to B7 have their frequencies divided by chains of frequency dividers 32 to 37 each effecting frequency division by two. First to fourth latching selectors 38 to 41 operatively coupled to a pedal keyboard 42 receive from the divider chains tone signals representing notes

C3 to C4, notes G4 to G5, notes E5 to E6 and notes D6 to D7 respectively. Outputs from the first to fourth latching selectors 38 to 41 are supplied to first to fourth frequency dividers 43 to 46 respectively. These frequency dividers effect frequency division by two, three, five and nine respectively. An output from the first frequency divider 43 is conducted to a first divider chain 47 comprised of frequency dividers 48 and 49 carrying out frequency division by two. An output from the second frequency divider 44 is supplied to a second divider chain 50 comprised of frequency dividers 51, 52 and 53 effecting frequency division by two. An output from the third frequency divider 45 is supplied to a third divider chain 54 comprised of frequency dividers 55, 56, and 57 carrying out frequency division by two. An output from the fourth frequency divider 46 is conducted to a fourth divider chain 58 comprised of frequency dividers 59, 60 and 61 carrying out frequency division by two. An output 08 from the first frequency divider 43, an output 08' from the first unit 51 of the second divider chain 50, an output 08'' from the first unit 55 of the third divider chain 54 and output 08''' from the first unit 59 of the fourth divider chain 58 have approximately and not exactly the same frequency. Similarly, outputs 016, 016', 016'' and 016''' from the frequency dividers 48, 52, 56 and 60 have approximately and not exactly the same frequency. Outputs 032, 032', 032'' and 032''' also have approximately and not exactly the same frequency. As shown in FIG. 8, the outputs 08, 016 and 032 obtained through frequency division by the ÷two divider 43, the outputs 08', 016' and 032' obtained via frequency division by the ÷three divider 44, the outputs 08'', 016'' and 032'' obtained via frequency division by the ÷five divider 45, and the outputs 08''', 016''' and 032''' obtained via frequency division by the ÷nine divider 46 are supplied to gate circuitries 71 to 74. The first to fourth gate circuitries 71 to 74 are operatively coupled to the pedal keyboard 42, and each include three gate circuits. Outputs from the individual gate circuits are fed to twelve manually operable switches S1 to S12. The outputs 08, 08', 08'' and 08''' are mixed via the switches S1, S4, S7 and S10 and in turn applied to first tone coloring filters 75. The outputs 016, 016', 016'' and 016''' are mixed via the switches S2, S5, S8 and S11 and in turn supplied to second tone coloring filters 76. The outputs 032, 032', 032'' and 032''' are mixed via the switches S3, S6, S9 and S12 and in turn supplied to third tone coloring filters 77. The abovementioned switches S1 to S12 are selectively closed as desired by a player, enabling the fundamental or harmonic tone signals to produce humming sounds. The player can selectively close the switches S1 through S12 singly or in combination at his choice to provide desired tone effects to meet the respective music requirements.

What is claimed is:

1. An electronic musical instrument comprising:
 - a plurality of tone generators;
 - keyboard means having a plurality of keys;
 - at least first and second latching selectors operatively coupled to said keyboard means, said first and second latching selectors each including:
 - input terminals connected to said plurality of tone generators,
 - a single output terminal, and
 - means coupled to said single output terminal for producing upon key depression respective first and

second single tone signals bearing a predetermined frequency relationship to each other, irrespective of the number of keys which are depressed;
 a first frequency divider connected to the output terminal of said first latching selector for dividing the frequency of said first tone signal by a first predetermined number to generate a frequency divided first signal;
 a second frequency divider connected to the output terminal of said second latching selector for dividing the frequency of said second tone signal by a second predetermined number to generate a frequency divided second signal, said second predetermined number being larger than said first predetermined number but not a power of a number 2 with respect to said first predetermined number; and
 means coupled to the outputs of said first and second frequency dividers for mixing said frequency divided first and second tone signals.

2. An electronic musical instrument according to claim 1 wherein said frequency divided signal has a frequency bearing a ratio of a substantially integral number of at least two to that of said frequency divided second signal.

3. An electronic musical instrument according to claim 1 wherein said frequency divided first signal has a frequency bearing a ratio of substantially one to that of said frequency divided second signal.

4. An electronic musical instrument according to claim 3 wherein said first predetermined number is two and said second predetermined number is an odd number larger than two.

5. An electronic musical instrument according to claim 4 wherein said odd number is three.

6. An electronic musical instrument according to claim 4 wherein said odd number is five.

7. An electronic musical instrument according to claim 2 wherein said first predetermined number is two and said second predetermined number is an odd number larger than two, and said frequency divided first tone signal has a frequency representing an approximately and not exactly integral multiple of that of said frequency divided second signal.

8. An electronic musical instrument according to claim 7 wherein said odd number is three.

9. An electronic musical instrument according to claim 1 further comprising first and second gate means respectively coupled between said mixer and said first frequency divider and between said mixer and said second frequency divider, said first and second gate means being operatively coupled to said keyboard means.

10. An electronic musical instrument according to claim 9 wherein said first gate means provides a sustained envelope to an output from said first frequency divider, and said second gate means provides a percussive envelope to an output from said second frequency divider.

11. An electronic musical instrument according to claim 10 wherein the output signal from said first frequency divider has a frequency bearing a ratio of substantially one relative to the frequency of the output signal from said second frequency divider, said first and second frequency dividers respectively effecting frequency division by two and five.

12. An electronic musical instrument according to claim 1 further comprising a gate means coupled to the

output of said mixer means and operatively coupled with said keyboard means.

13. An electronic musical instrument according to claim 1 wherein the second predetermined number associated with said second frequency divider is an odd number larger than two, and there is further provided a third frequency divider cascade connected to the output of said second frequency divider for dividing the frequency of a signal by an even number.

14. An electronic musical instrument according to claim 13 wherein said even number is two.

15. An electronic musical instrument according to claim 1 wherein said keyboard means comprises a pedal keyboard.

16. An electronic musical instrument according to claim 1 wherein the first predetermined number associated with said first frequency divider is two, and the second predetermined number associated with said second frequency divider is an odd number larger than two, and which further includes a first chain of frequency dividers cascade connected to the output of said first frequency divider, the respective frequency dividers of said first chain effecting frequency division by two; a second chain of frequency dividers cascade connected to the output of said second frequency divider, the respective frequency dividers of said second chain effecting frequency division by two; and a plurality of manually operable switches for selectively coupling the outputs of said first frequency divider and the respective frequency dividers of said first and second chains said mixer means.

17. An electronic musical instrument according to claim 16 wherein an output from said first frequency divider has a frequency bearing a ratio of substantially one relative to the frequency of the output signal from the first frequency divider of said second chain of frequency dividers, said first frequency divider of said second chain of frequency dividers being connected to the output of said second frequency divider.

18. An electronic musical instrument according to claim 1 wherein said first predetermined number associated with said first frequency divider is two and said second predetermined number associated with said second frequency divider is a first odd number larger than two, and further comprising at least third and fourth latching selectors operatively coupled with said keyboard means; a first chain of frequency dividers cascade connected to the output of said first frequency divider, the respective frequency dividers of said first chain effecting frequency division by two; a second chain of frequency dividers cascade connected to the output of said second frequency divider, the respective frequency dividers of said second chain effecting frequency division by two; a third frequency divider connected to the output of said third latching selector for effecting frequency division by a second odd number larger than said first odd number; a third chain of frequency dividers cascade connected to the output of said third frequency divider, the respective frequency dividers of said third chain effecting frequency division by two; a fourth frequency divider connected to the output of said fourth latching selector for carrying out frequency division by a third odd number larger than said second odd number; a fourth chain of frequency dividers cascade connected to the output of said fourth frequency divider, the respective frequency dividers of said fourth chain effecting frequency division by two;

and a plurality of manually operable switches for selectively coupling to said mixer means the outputs of said first frequency divider, and the respective frequency dividers constituting said first, second, third and fourth chains.

19. An electronic musical instrument according to claim 18 wherein an output from said first frequency divider, an output from the first frequency divider of said second chain, an output from the first frequency divider of said third chain and an output from the first frequency divider of said fourth chain have frequencies which mutually have ratios of substantially one-to-one.

20. An electronic musical instrument according to

claim 18 wherein said first, second, and third odd numbers are three, five and nine, respectively.

21. An electronic musical instrument according to claim 18 further comprising gate means connected between the output of the respective frequency dividers of said first to fourth chains and said plural switches, said gate means being operatively coupled with said keyboard means for supplying outputs from the frequency dividers to the corresponding switches.

22. An electronic musical instrument according to claim 7 wherein said odd number is five.

23. An electronic musical instrument according to claim 7 wherein said odd number is nine.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,790,693 Dated February 5, 1974

Inventor(s) Takeshi ADACHI

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On initial page of patent under the heading of
Foreign Application Priority Data

add the following:

--June 21, 1972 Japan..... 73332/72--;

Column 7, line 22, after "divided" insert --first--;

Column 8, line 31, after "chains" insert --to--;

Column 8, line 45, after "comprising" insert --:--.

Signed and sealed this 9th day of July 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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